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# TIME ERROR IN PERCEPTION OF SOUND BRIGHTNESS

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## Introduction

The method of paired comparisons is one of the most popular procedures in psycho-acoustic experiments. In some cases, though, the results obtained are not error-free. Biasing effects can come from many sources. The time error (TE) is one of them. The term time error refers to the systematic asymmetries that arise in comparisons of stimuli presented pairwise, separated by a time interval. Some investigations have shown that the TE depends on the inter-stimulus interval (ISI), because of both memory and masking factors. It is generally assumed that the significance of the memory factor increases for long ISI's but the significance of the masking factor is the greatest for short ISI's. The minimisation or, at least, the knowledge of the character of the TE, is obligatory to draw valid conclusions from experimental data. The TE is assumed to be equal to zero when objectively the same stimuli (in the paired comparison method) are judged to be identical by the subjects. The TE has a negative or positive value if the investigated feature in the first stimulus is under- or over-estimated, respectively, in relation to the second. When pair-wise stimuli differ from one another in respect of an investigated feature, the subjects have an additional tendency to overestimate the existing difference.

Some data on the auditory time error for loudness and pitch perceptions have been presented over the last 60 years. Köhler [2], Postman [6] and Pollack [5] demonstrated the existence of ISI values for TE equalled zero, was negative or positive for loudness perception. The results varied depending on the experimental procedures. Where the pitch of tones is concerned there is no agreement between investigators as to the existence of TE. Some experiments showed the positive TE for ISI shorter than 300 ms (Massaro [4], Jaroszewski & Rakowski [1]). Other data did not demonstrate any time error, positive or negative (Truman & Wever [7], Koester [3], Postman [6]).

However, there are still no data on the TE occurring in a sequential comparison of sound timbres. This problem seems to be especially important nowadays due to the wide interest in multidimensional scaling of timbre and the development of sound quality evaluation methods. For that reason the preliminary experiment on the TE for perception of one dimension of timbre, namely brightness of sound, was carried out.

## Procedure

In the first experiment samples two seconds long of wide band noise were compared in respect of brightness of sound impression. In each sequence two stimuli were separated with ISI of 0.1, 0.2, 0.5, 1, 2, 4 or 8 s. A white noise signal was a reference stimulus (designated "0"). For each value of ISI

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four "O-O" type test sequences were presented (28 trials). In the other trials one of the stimulus was high-pass or low-pass noise. Two high-pass and two low-pass signals were produced from the reference stimulus with the help of Brüel & Kjaer Spectrum Shaper 5587 with cut-off frequencies 14.1 kHz (signal "1") or 11.2 kHz (signal "2") and 141 Hz (signal "3") or 178 Hz (signal "4") (Fig.1). All sequences O-1, 1-O, O-2, 2-O etc. were presented once for each of the investigated ISI values. The test consisted of 84 trials presented at random. The pause between successive trials was equal to 5 s. Each trial was preceded by an attention signal - a short pulse of 1 kHz sine wave. The duration of the whole test was about 16 minutes (Fig.2).

The test was recorded on and played back from a Revox A77 tape recorder. The frequency range of the electroacoustic chain was equal to 40-18000 Hz ± 3 dB. The tests were presented in a sound control room at loudness level of 80 phons. Fifteen students and research staff of the Sound Engineering Department took part in the experiment. They were presented with two stimuli in each trial and were required to judge which was perceived as "brighter". The subjects could not answer: "I do not know" or "Both stimuli are identical".

In the second test a four-bar fragment of the accordion music was a reference stimulus. The ISI values were the same. The spectrum shaper with the same four different frequency response characteristics, as in the first test, was used to prepare signals "1", "2", "3" and "4". The experimental procedure was identical with the previous one.

Results

The results of the first experiment for "O-O" type trials are presented in Table 1.

Table 1

| ISI [s] | Proportion of the choice of the first or the second stimulus in a pair | The value of z statistics |
|---|---|---|
| 0.1 | 27:33 | -0.77 |
| 0.2 | 34:26 | 1.03 |
| 0.5 | 33:27 | 0.77 |
| 1.0 | 35:25 | 1.29 |
| 2.0 | 25:35 | -1.29 |
| 4.0 | 20:40 | -2.58 |
| 8.0 | 18:42 | -3.10 |

The data were compared against the hypothesis that the choice of the first or the second signal in a pair was equally probable. The test of significance of a difference between two proportions (z-test) was made at a significance level $\alpha = 0.1$. The z-values for ISI of 0.1 - 2 s indicated the lack of the TE for the evaluation of sound brightness - subject responses had the random distribution. For ISI's equal to 4 and 8 s z-values pointed out the existence of negative value of the TE, i.e. the subjects overestimated brightness of

sound for the second stimulus.

For mixed pairs of stimuli the subjects perceived all the differences in brightness correctly. The total number of errors did not exceed 10%. Moreover, the distribution of errors showed that the difficulty of the test increased according to the value of ISI.

Very similar results were obtained for the second test containing musical signals. The data indicated the negative value of the TE for ISI's equal to 4 and 8 s and the lack of the TE for shorter ISI's. The details will be presented during the meeting.

## Conclusions

The experimental data showed the lack of the distinct TE for sound brightness for ISI of 0.1 - 2 s. Longer ISI's indicated the existence of negative value of the TE. It seems to justify the hypothesis that auditory memory is better for lower than for higher components of the spectrum. This hypothesis requires, however, to be confirmed by subsequent experimental investigations.

## References

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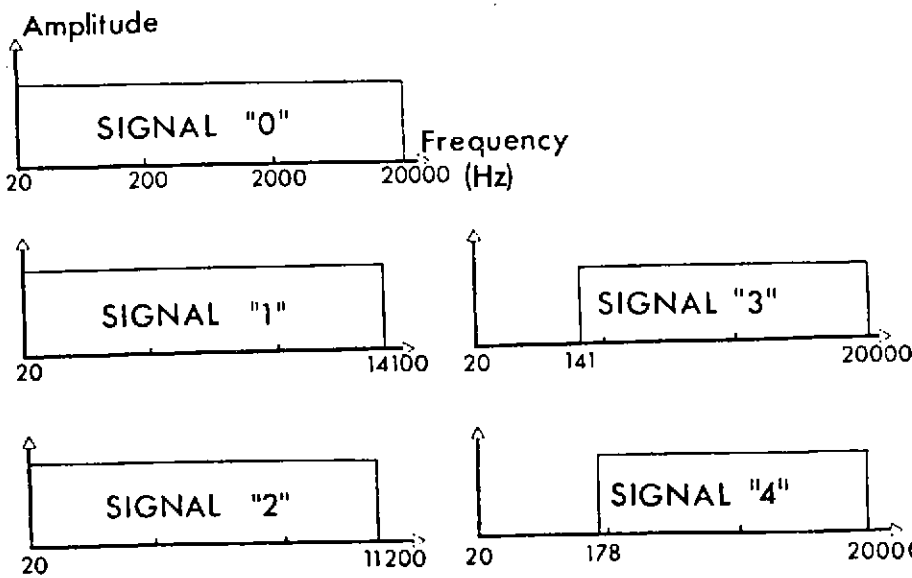


Fig.1 Spectra of noise signals

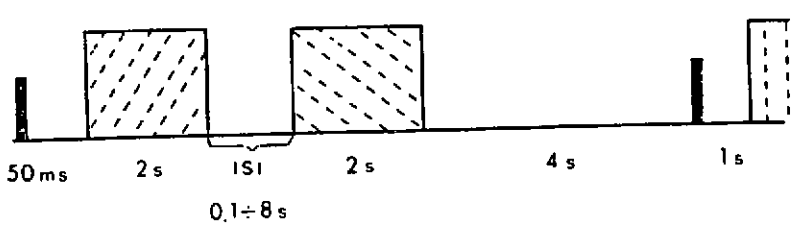


Fig. 2 Time paradigm of trial